

# GLAST



## **Multiwavelength Pulsar Observations in Support of GLAST**

**Steve Thorsett**

**GLAST Interdisciplinary Scientist**

**UC Santa Cruz**

(reporting on work including many people in the GLAST Pulsar, SNR, Plerion Science Group, particularly Roger Romani, David Smith & Dave Thompson)

**GLAST**



## Pulsar Science with GLAST

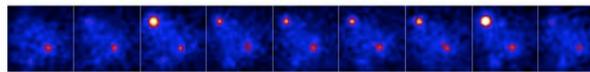
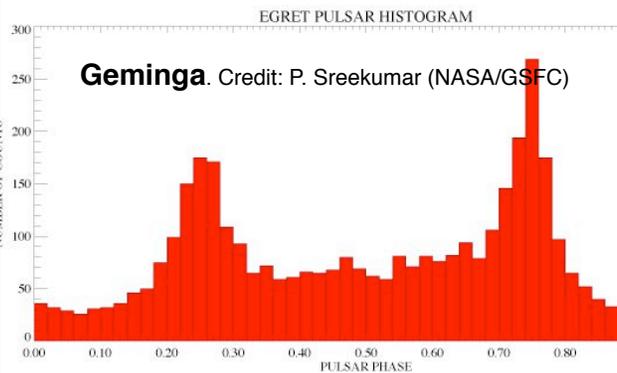
---

- Studies of rotation-powered pulsars (aka “radio pulsars”):
  - a **major driver** for the design of the mission
  - an expected **highlight** of GLAST science
- Science has been summarized well elsewhere:
  - talks by Harding, Johnston, Ransom
  - *many* posters in group P14
- We’ve got to do this right, and keep doing it right through the entire GLAST mission

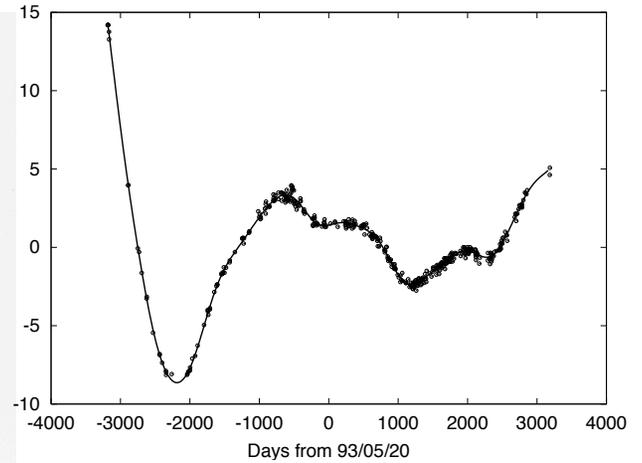
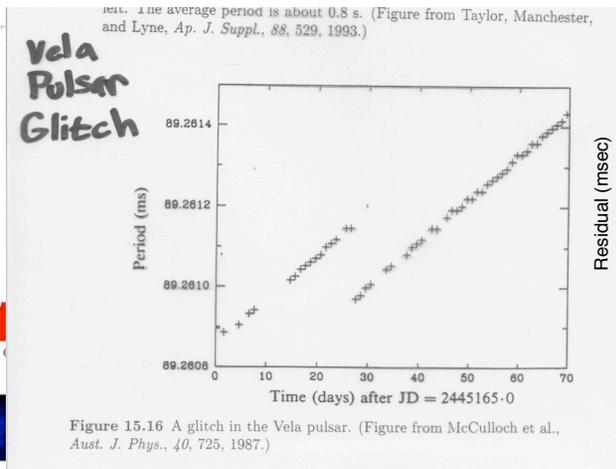


# Challenge 1: Time variability

- Pulsar rotational phase varies periodically on short timescales (with linear slow-down)
- Phase wanders on long timescales (timing noise, typically 0.1-10% in 3 yrs, growing like  $T^3$ )
- Frequency can jump abruptly (glitches, rare)



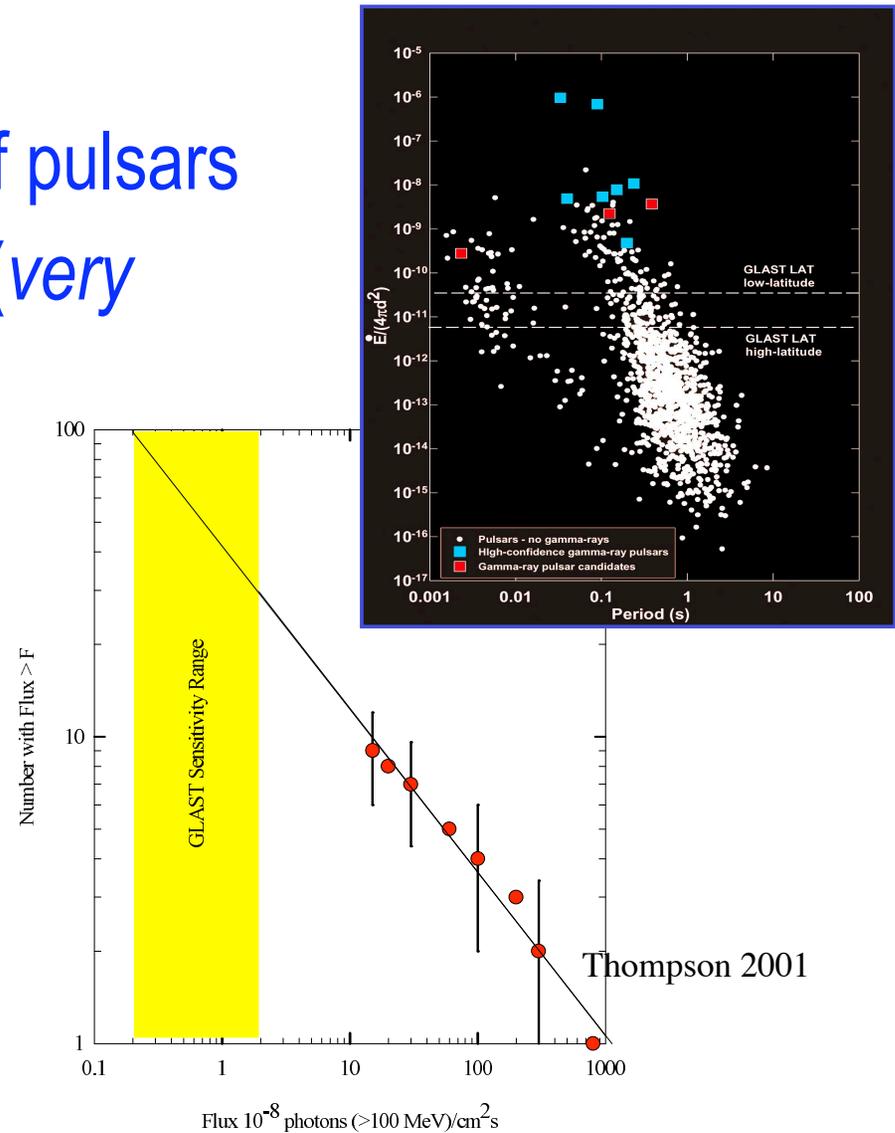
Pulsar Name: 0630+17 Galactic Coords: 195.13, 4.27 Period: 237.1ms Energy: >100 Mev Chi-Squared: 8332.54





## Challenge 2: GLAST sensitivity

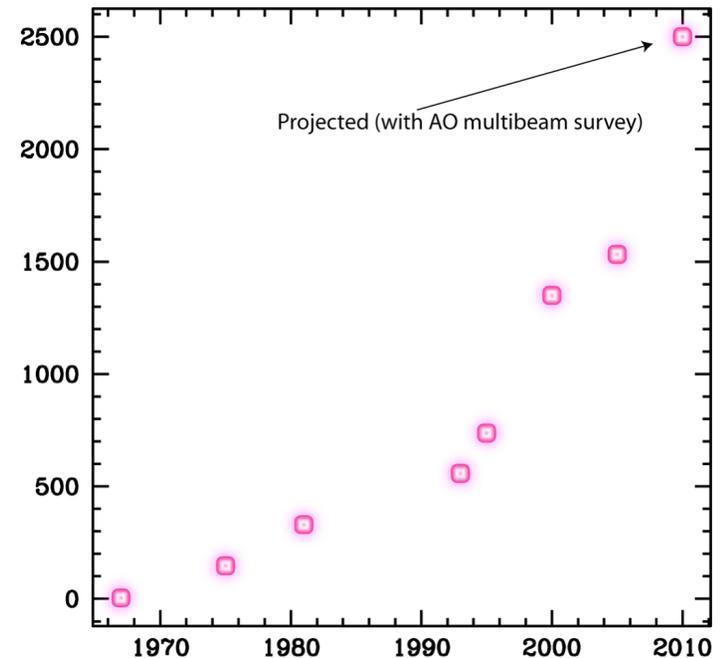
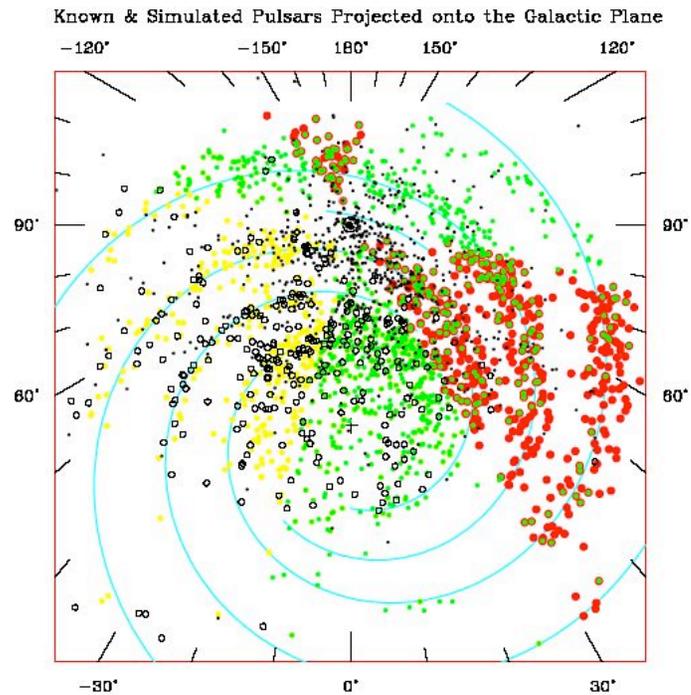
- CGRO saw just a handful of pulsars
  - GLAST may see hundreds (*very uncertain*)
  - Most will be near threshold, requiring many months to years of integration
- ➔ Phase wander must be monitored for hundreds of pulsars over a period of years





## Challenge 3: Numerous, faint radio sources

- Pulsars are discovered with the largest radio telescopes, and must be followed up with the same
- New surveys are finding *many* faint, distant pulsars



GLAST

# GLAST



## The EGRET Experience

---

- The CGRO era was marked by outstanding cooperation between the high-energy and radio communities, with large radio programs led by Lyne (Jodrell), Manchester (Parkes), and Taylor (Green Bank)
- Over 300 pulsars were timed, but many only semi-annually and many more only quarterly
- Only a few dozen were really needed with high precision, because of the low gamma-ray sensitivity

---

**GLAST**



# The EGRET Experience

- Green Bank 140-foot
  - 120 attempted, 96 timed quarterly (Arzoumanian, Nice, Taylor & Thorsett 1994)
  - four frequencies
  - milliperiod measurement uncertainties
  - timing noise estimates

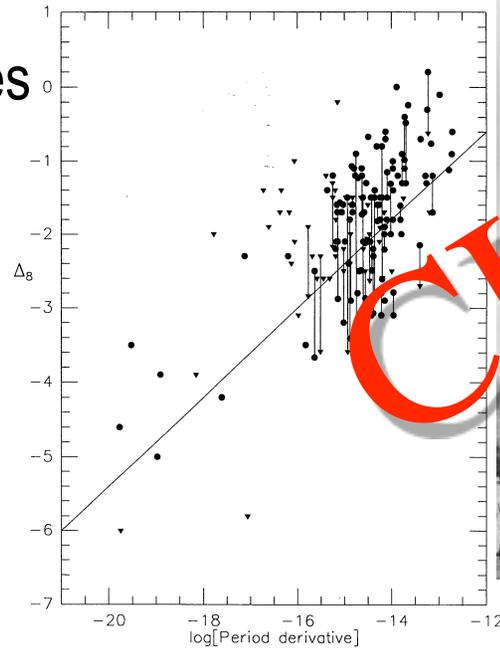


FIG. 1.—The timing noise parameter,  $\Delta_8$ , plotted as a function of period derivative for 139 pulsars. Inverted triangles represent upper limits. When two or more estimates of  $\Delta_8$  are available, the corresponding plotted points are connected by vertical lines.



# GLAST



## The EGRET Experience

- Green Bank 85-foot
  - 35 strong pulsars observed daily (Nice, Taylor & Stinebring 1990)
  - ~two frequencies
  - daily observations ideal for glitch monitoring



GLAST



## The EGRET Experience

- Lovell 76-m at Jodrell
  - About 320 pulsars timed
  - about 160 semi-annually
  - about 160 quarterly
  - program is continuing: over 500 pulsars are now regularly timed and Hobbs et al. (2004) recently published 374 ephemerides





## The EGRET Experience

---



- Parkes 64-m
  - The only large southern telescope with a major pulsar program
  - Has discovered most known southern pulsars
  - Maintains a large timing program, with numerous papers on subsets of population but no single summary paper (that I know of)



## Defining the problem

---

- It is **impossible** to time all known pulsars during the GLAST mission
- Therefore we prioritize: see Romani poster 14.18
- The (extended) LAT collaboration working group has identified:
  - 215 total pulsars to attempt to obtain regular timing data
  - 152 of these are high priority “must-do pulsars”
  - 63 are lower priority “would-like-to-do pulsars”
  - full list is at <https://confluence.slac.stanford.edu/display/GLAMCOG/Pulsar+Timing>



## GLAST Workhorses

---

The two most critical telescopes are Jodrell in the north and (especially) Parkes in the south



Has observed 90 priority pulsars in 2006,  
with 35 good, 18 OK, and 37 poor



Has observed 125 priority pulsars in 2006



## Other important radio telescopes

---

Nançay telescope in France



Has observed 71 of 215 GLAST pulsars in the last few years (Cognard)

---

**GLAST**



## Other important radio telescopes

---

### Arecibo Observatory



Proposal for 22 pulsars, but outlook is very uncertain given current and expected cuts



## Other important radio telescopes

---

### Green Bank Telescope



Will be **very** important for particular high-priority northern pulsars. Has high oversubscription and long-term scheduling challenges.



## Other important radio telescopes

---



Mt Pleasant 14m for Vela



42ft at Jodrell for Crab



Nanshan 25m



Effelsberg 100m

Others??

# GLAST



## Non-radio timing

---

RXTE



Marshall, Kaspi, et al., have proposed a handful of radio-faint pulsars:  
J1811-1925, J1846-0258, LMC pulsars, plus DM monitoring

---

**GLAST**



## Summary

---

- David Smith is tracking match between planned observations and target list for LAT team
- Two dozen pulsars south of -40 dec are “orphans”
  - 14 of these are “must do”
- Three pulsars north of 40 dec are “orphans”
  - one is a “must do” (J1808-2022)
  - there may be options with Effelsberg (Kramer), GBT, or Arecibo
- We’re doing pretty well:
  - 90% of “must do” pulsars have a telescope attached
  - the top 75 pulsars on our list all have associated telescopes
  - but **quality** of timing is variable and in some cases poor

# GLAST



## Your tasks

---

- Review the list of priority pulsars
  - read Roger's poster
  - nominate additional pulsars to me, Roger, or David
- Support the continuation and extension of the large scale timing programs at Jodrell, Nançay, and Parkes
  - lots of hard work needs to be done!
- If *your* priority pulsars are being missed, consider targeted proposals at GBT, Arecibo, or other telescopes
  - we can help facilitate gamma-ray/radio connections
  - June 1 is the critical US radio telescope deadline

---

**GLAST**